

PATENT APPLN. NO. 10/531,045
RESPONSE UNDER 37 C.F.R. §1.111

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REMARKS

Claim 1 has been amended to precisely recite that the thin film composed entirely or mainly of silicon of the negative electrode of the rechargeable lithium battery of the present invention undergoes an increase in porosity that advances inside from the thin film surface during charge and discharge and that the addition of carbon dioxide to the nonaqueous electrolyte according to the present invention suppresses the increase in porosity during charge and discharge. This amendment is supported in the specification of the present application in paragraphs [0005] and [0017].

Claim Rejections - 35 USC § 103

Referring to the Action, the Office is again rejecting claims 1-5, 8-10, 12-17 and 22 as being unpatentable under 35 U.S.C. § 103(a). The Office is relying on the same primary references cited in the Final Action of January 26, 2009, i.e., JP 2003-007295 ("JP '295") and JP 01-029913 ("JP '913"), for the disclosure of a rechargeable lithium battery in which the negative electrode comprises a noncrystalline (amorphous) silicon thin film which may contain cobalt or iron.

The Office is also relying on the same teaching references, i.e., Ebner et al., U.S. Patent No. 4,853,304 ("Ebner") and JP-07-

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249431 ("JP '431"), cited in the Final Action as supporting the obviousness of adding carbon dioxide to the non-aqueous batteries of JP '295 and JP '913 to improve the cycling efficiency and as teaching a roughness of the current collector of 0.1 micron to improve the adhesion of the thin film on the current collector.

The Office has cited a new teaching reference, Ikeda et al., EP 1 231 651 A1 ("Ikeda"), as teaching the obviousness of including columns and gaps in an amorphous silicon thin film.

Applicants Remarks

The primary issue raised by the present rejections is essentially the same as that raised by the rejections in the Final Action of January 26, 2009. This issue is whether a person of ordinary skill in the art would have been motivated or have had a proper reason, in view of Ebner and JP '431, to add carbon dioxide to the battery of either JP '295 or JP '913. The citation of the new reference, Ikeda, does not change this issue.

Therefore, the arguments made in response to the rejections in the Final Action and the Office's response to those arguments are relevant to the present rejections.

In response to the rejections in the Final Action, applicants argued that a person of ordinary skill in the art could not have reasonably predicted, from the cited references, the effects of

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adding carbon dioxide to a rechargeable lithium battery including a negative electrode made by depositing a noncrystalline thin film composed entirely or mainly of silicon on a current collector as in the present invention.

Applicants noted the different negative electrode material (lithium metal) used in Ebner and the effect of CO₂ in Ebner to form an ionically conductive, protective film on the surface of the lithium metal.

With respect to JP '431, applicants noted the different purpose and effect of dissolving carbon dioxide in the electrolyte of the battery. Applicants also noted that JP '431 does not disclose silicon as a negative active material.

The Office did not find these arguments to be persuasive. In the Advisory Action dated May 6, 2009, the Office took the position that it does not matter what the anode material is in the batteries, the carbon dioxide is added to improve the characteristics of the batteries. The office noted that Ebner adds the carbon dioxide to improve the properties of the battery and that adding carbon dioxide in JP'431 would prevent a fire from starting in the non-aqueous battery.

The Office's reasoning is clearly not correct with respect to Ebner. The invention of Ebner is specifically directed to the

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effect of carbon dioxide in lithium secondary batteries utilizing anodes of lithium metal. The Office has provided no reasoning or evidence showing that the effect of the addition of carbon dioxide in Ebner would be expected to be exhibited in lithium rechargeable batteries utilizing a noncrystalline thin film composed entirely or mainly of silicon as the anode material.

With respect to JP '431, if the effect of carbon dioxide does not depend on the type of negative electrode material, it cannot be necessarily concluded that a person of ordinary skill in the art would have been motivated to add carbon dioxide to the electrolyte of all rechargeable lithium batteries (as the rejection of the Office assumes).

If the dissolution of carbon dioxide in nonaqueous electrolyte provided only advantages, carbon dioxide would necessarily be dissolved in the nonaqueous electrolytes of all rechargeable lithium batteries. However, it is well known in the art that carbon dioxide is not dissolved in nonaqueous electrolytes in most cases. This is because the dissolution of carbon dioxide in nonaqueous electrolytes provides disadvantages. If a temperature of a battery increases, carbon dioxide dissolved in a nonaqueous electrolyte is released from the nonaqueous electrolyte to cause an increase in thickness of the battery and in an internal pressure of

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battery. Actually, JP '431 discloses the following in paragraph [0024]:

[0024] If carbon dioxide is dissolved into said nonaqueous electrolyte exceeding saturation solubility of carbon dioxide at 45 °C, inconvenience arises practically because explosion-proof function may operate by the slight rise of service temperature of said rechargeable battery.

Therefore, a person of ordinary skill in the art would not have been motivated to dissolve carbon dioxide in the nonaqueous electrolyte merely because of the effect disclosed in JP'431. A dramatic actual advantage would have to have been expected. The effects of carbon dioxide in the present invention provide such dramatic, albeit unexpected, advantage.

In a battery including a negative electrode made by depositing a noncrystalline thin film composed entirely or mainly of silicon on a current collector, silicon repeatedly expands and contracts during charge and discharge to result in an increase of porosity therein. In the present invention, the inclusion of carbon dioxide in the nonaqueous electrolyte, in addition to carbon dioxide formed during fabrication of the battery, suppresses the increase in porosity (as now recited in the claims). Such effect is not

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observed in other negative active materials such as lithium metal or carbon materials used as negative electrode active materials in conventional lithium batteries.

The effects of carbon dioxide in the present invention are not expected from the effects of the prior art lithium batteries in which carbon dioxide is dissolved in the nonaqueous electrolyte.

Applicants again emphasize that the data of the "REFERENCE EXPERIMENT" (paragraphs [0068] - [0081] of the present specification), show that the effects of the present invention are not obtained when using a carbon material as negative electrode material. This is an unexpected effect.

In the Advisory Action, the Office stated that this argument was not convincing "because all of the applied references set forth anode materials other than carbon." The relevance of this statement to the issue of whether the data in the "REFERENCE EXPERIMENT" demonstrate unexpected results is not understood. It is not necessary for applicants to show that the effects of the present invention are not obtained when using all possible anode materials, in the absence of evidence or reasoning by the Office showing that other anode materials would be expected to show different effects than carbon.

If the Office maintains the position that the data of the

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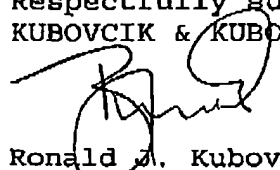
"REFERENCE EXPERIMENT" do not demonstrate unexpected results, the Office is requested to provide proper reasoning and/or evidence supporting its position.

For the above reasons, the prior art of record does not support the 35 U.S.C. § 103(a) rejections of claim 1 and the claims that depend thereon. Withdrawal of the 35 U.S.C. § 103(a) rejections is respectfully requested.

The foregoing is believed to be a complete and proper response to the Office Action dated September 8, 2009.

In the event that this paper is not considered to be timely filed, applicants hereby petition for an appropriate extension of time. The fee for any such extension and any additional required fees may be charged to Deposit Account No. 111833.

Respectfully submitted,
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